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Editorial

Special Issue: Numerical Simulation and Thermo-Mechanical Investigation of Composite Structures

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Material behavior is the key aspect of composite research [1]. The important attributes that demand current research are understanding material behavior, predictive modeling, performance enhancement, and safety and reliability [2,3]. Temperature and mechanical loads are dangerous in combination and cause failure [4]. Research on this topic needs to explore mechanical and thermal behavior to understand how composite materials behave under thermal and mechanical loads, mainly including the combined effect of temperature on mechanical properties. However, experimental work gives accurate predictions based on the data, but it is costly and time-consuming [5,6]. Modeling and simulation work can be developed that are reliable and comparable to experimental results [7,8]. However, they need to be validated to rely on the developed models so that they can be used to identify the failure and design stage. This leads to performance enhancement and involves identifying design modifications for new materials. The goal is to understand modeling and simulation for reliability and safety to designthe material behavior under working conditions.

This is significant to improve the performance of composite structures in various industries, including aerospace, automotive, civil engineering, etc. [9]. By optimizing material usage and improving performance, research works can reduce the environmental impact of composite material manufacturing. Understanding how composite materials behave under different thermal and mechanical conditions is crucial for ensuring structures' safety and long-term durability. The related investigations need to explore the development of advanced materials with tailored thermo-mechanical properties, expanding the possibilities for engineering applications [10,11]. By enhancing material selection and design, studies have the potential to lead to more cost-effective manufacturing processes and product ornamental competitiveness in various industries.

Furthermore, understanding composite materials' behavior under varying temperatures is crucial for ensuring the safety and reliability of critical components [12–14]. Optimizing composite structures for thermal performance can lead to more energy-efficient systems, such as designing high-performance aircraft or renewable energy components.

The relevant research areas include material characterization, numerical simulation, failure analysis, design optimization, manufacturing processes, safety and reliability assessment, heat transfer, multiphase coupling, experimental validations, and many more. Material characterizations investigate composite materials' thermal and mechanical properties [15,16]. This includes understanding how different materials and manufacturing processes affect these properties. Numerical simulations develop and refine numerical models using techniques like finite element analysis (FEA) to simulate the behavior of composite structures under thermo-mechanical loads [17–19]. These mainly examine the distribution of stresses and strains within composite materials under different loading conditions. Failure analyses study the failure modes of composite structures under thermal mechanical stress. This includes delamination, buckling, fiber breakage, thermal cracking, etc., and developing strategies for preventing or mitigating them [20–23]. Design optimizations use simulation results to optimize the design of composite structures to withstand

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thermal and mechanical stresses, while minimizing weight and cost [24–26]. Manufacturing processes investigate how manufacturing processes, such as curing temperatures and pressures, affect the final properties of composite materials and structures [27–29]. Real-world applications apply research findings to real-world applications, such as aircraft components, automotive parts, and renewable energy systems [30–33]. Safety and reliability assessments develop methods for assessing the safety and reliability of composite structures, particularly in extreme temperature environments [34–36]. Heat transfer analyses explore how heat is distributed within composite structures, considering factors like conduction, convection, and radiation [37–40]. Multi-physics couplings show the interactions between thermal, mechanical, and other physical phenomena that influence the behavior of composite structures [41,42]. Also, experimental validations can be conducted to validate numerical simulations and ensure their accuracy in predicting real-world behavior. These summarized research areas may be covered in the works included in this Special Issue [43–46]. The goal, significance, and research area of these studies show the importance of thermal-mechanical simulation work.

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